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**Cowles et al.**

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(54) **DATA SHIFTING**

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See application file for complete search history.

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of Embedded Computing—Issues in embedded single-chip  
multicore architectures.

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(57) **ABSTRACT**

The present disclosure includes apparatuses and methods  
related to data shifting. An example apparatus comprises a  
first memory cell coupled to a first sense line of an array, a  
first isolation device located between the first memory cell  
and first sensing circuitry corresponding thereto, and a  
second isolation device located between the first memory  
cell and second sensing circuitry corresponding to a second  
sense line. The first and the second isolation devices are  
operated to shift data in the array without transferring the  
data via an input/output line of the array.

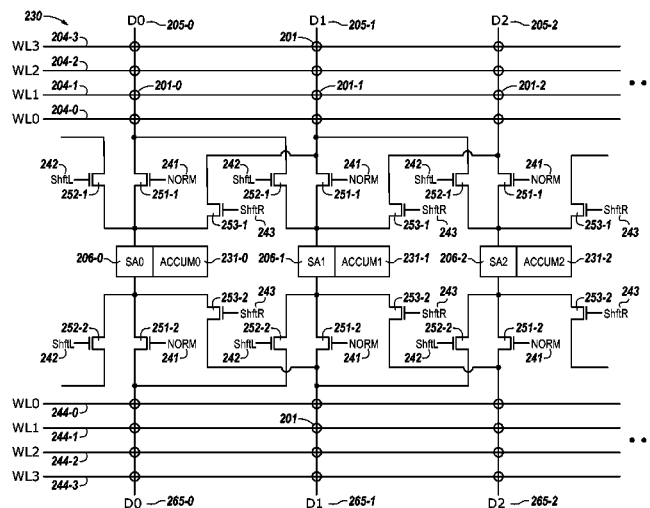
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**19 Claims, 5 Drawing Sheets**



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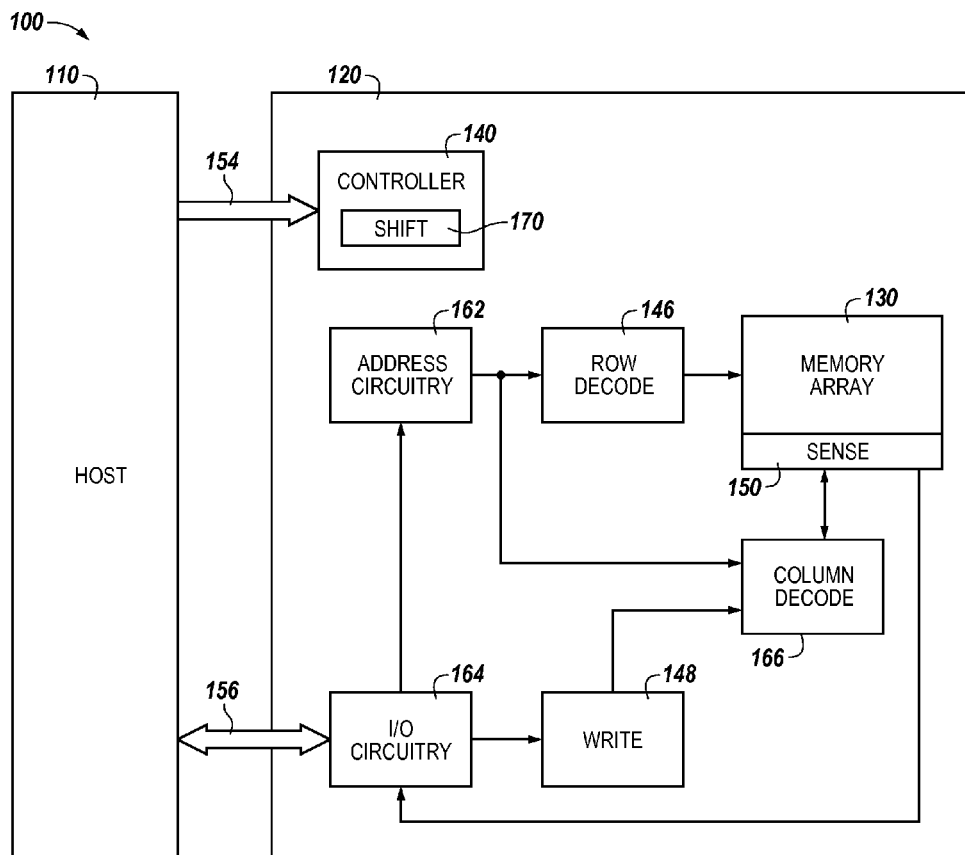
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*Fig. 1*

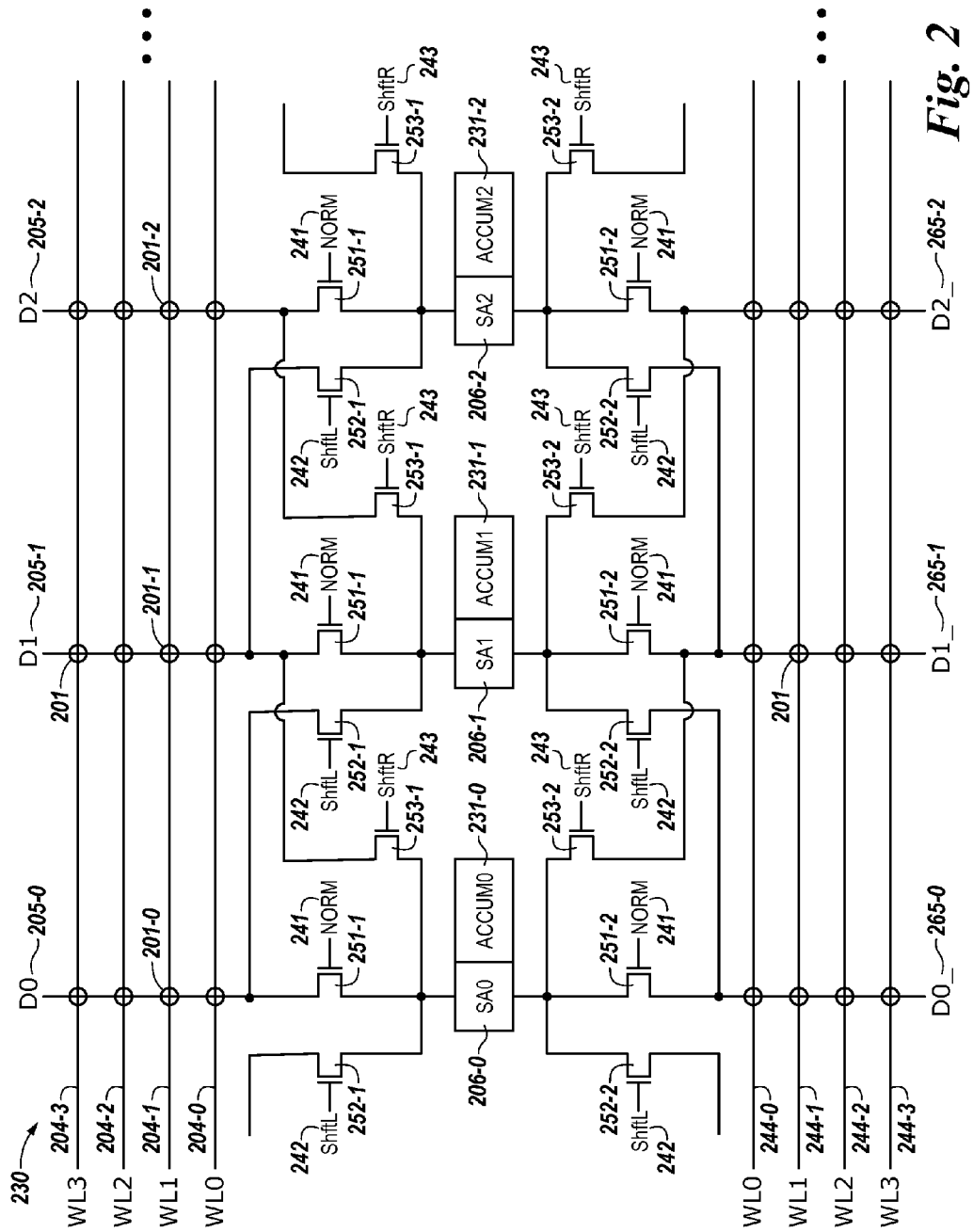


Fig. 2

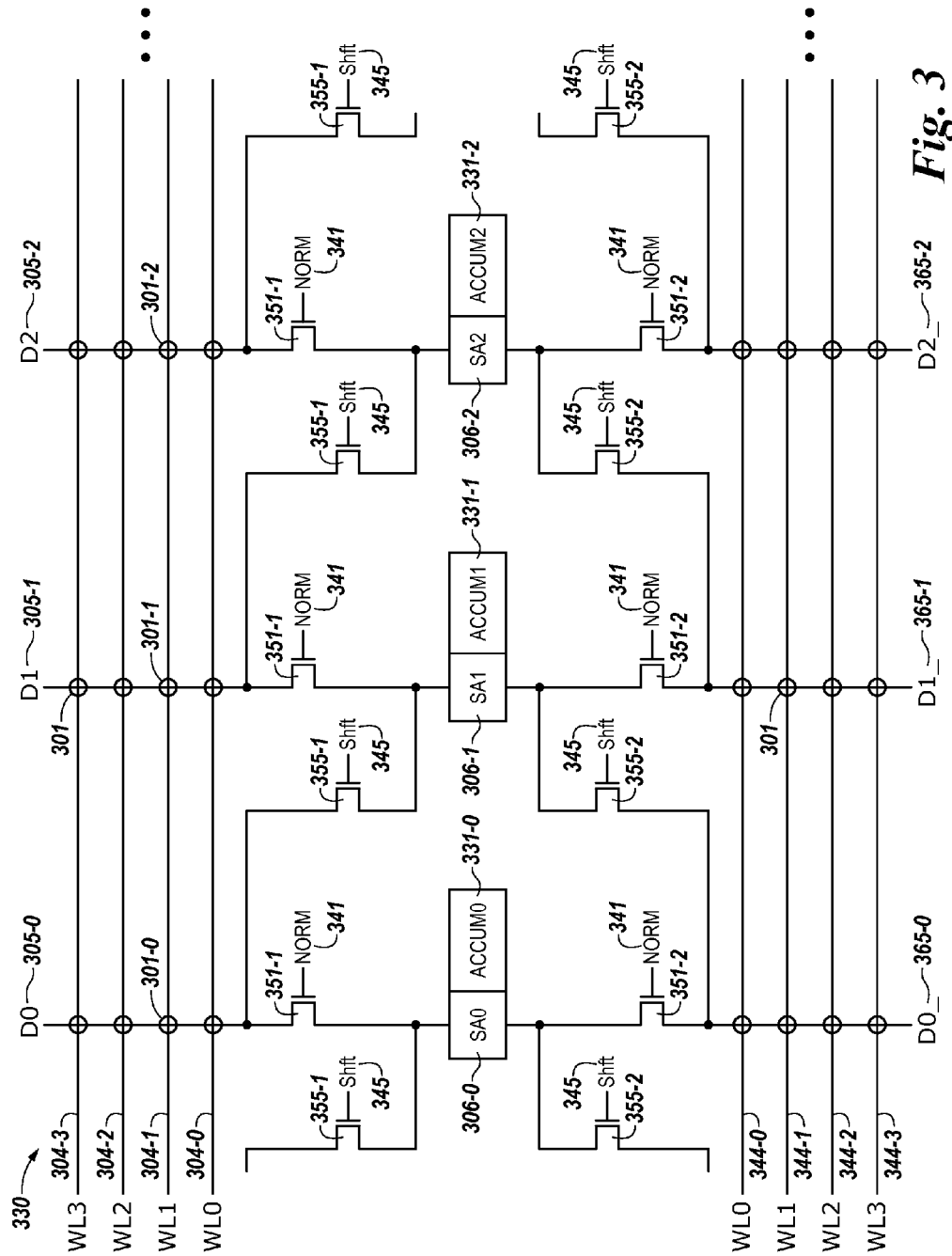
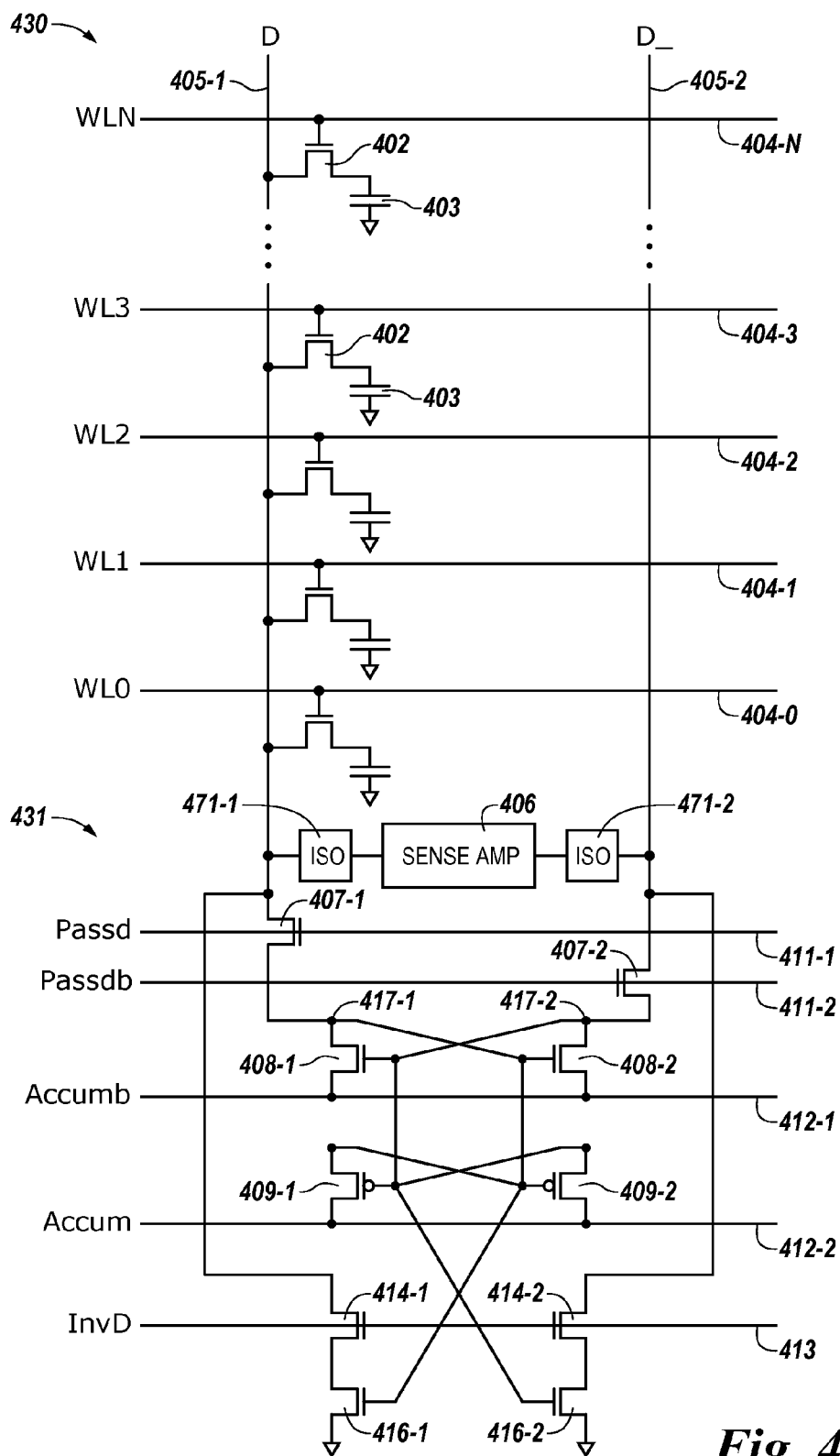
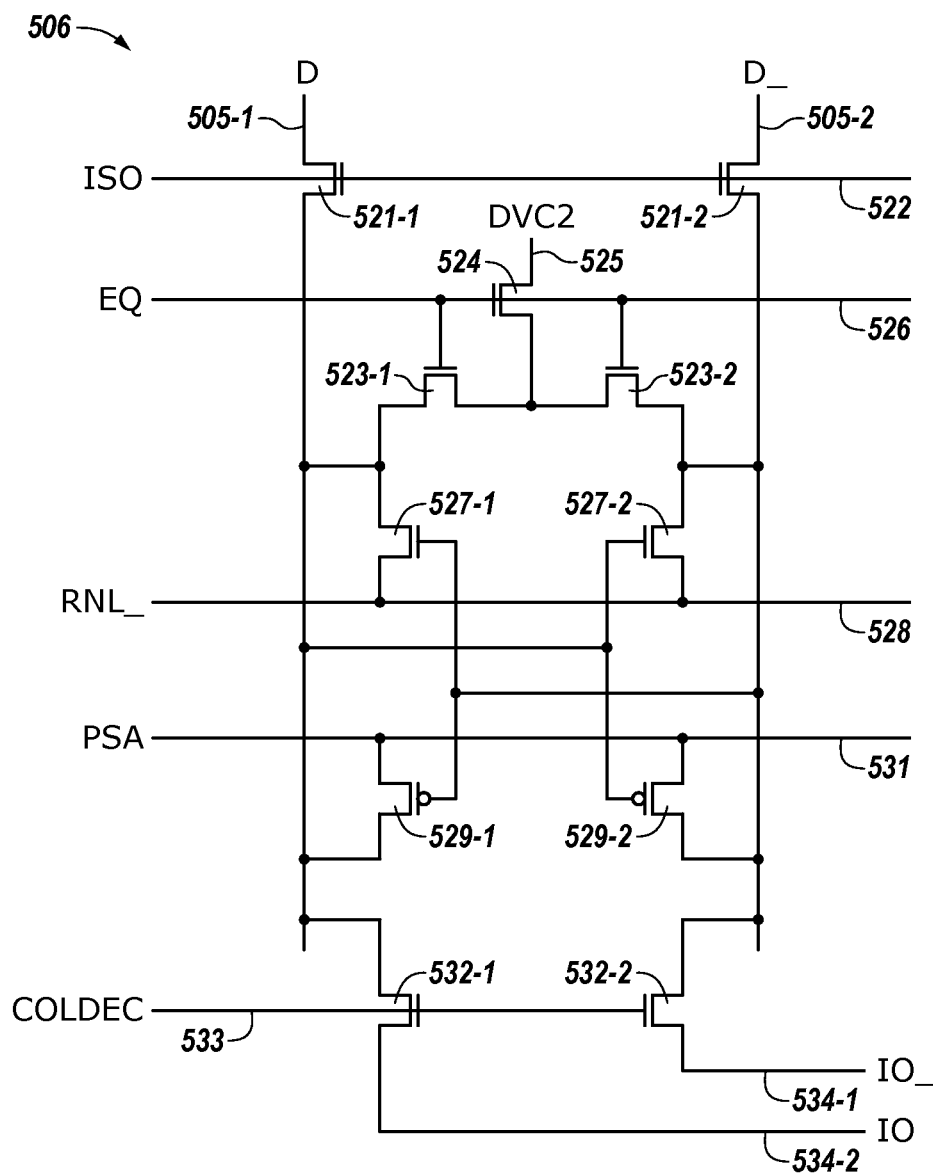


Fig. 3







*Fig. 5*

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**DATA SHIFTING****PRIORITY INFORMATION**

This application is a Continuation of U.S. application Ser. No. 14/031,432, filed Sep. 19, 2013, the contents of which are incorporated herein by reference.

**TECHNICAL FIELD**

The present disclosure relates generally to semiconductor memory and methods, and more particularly, to apparatuses and methods related to performing data shifting.

**BACKGROUND**

Memory devices are typically provided as internal, semiconductor, integrated circuits in computers or other electronic systems. There are many different types of memory including volatile and non-volatile memory. Volatile memory can require power to maintain its data (e.g., host data, error data, etc.) and includes random access memory (RAM), dynamic random access memory (DRAM), static random access memory (SRAM), synchronous dynamic random access memory (SDRAM), and thyristor random access memory (TRAM), among others. Non-volatile memory can provide persistent data by retaining stored data when not powered and can include NAND flash memory, NOR flash memory, and resistance variable memory such as phase change random access memory (PCRAM), resistive random access memory (RRAM), and magnetoresistive random access memory (MRAM), such as spin torque transfer random access memory (STT RAM), among others.

Electronic systems often include a number of processing resources (e.g., one or more processors), which may retrieve and execute instructions and store the results of the executed instructions to a suitable location. A processor can comprise a number of functional units such as arithmetic logic unit (ALU) circuitry, floating point unit (FPU) circuitry, and/or a combinatorial logic block, for example, which can be used to execute instructions by performing logical operations such as AND, OR, NOT, NAND, NOR, and XOR logical operations on data (e.g., one or more operands). For example, the functional unit circuitry may be used to perform arithmetic operations such as addition, subtraction, multiplication, and/or division on operands.

A number of components in an electronic system may be involved in providing instructions to the functional unit circuitry for execution. The instructions may be generated, for instance, by a processing resource such as a controller and/or host processor. Data (e.g., the operands on which the instructions will be executed) may be stored in a memory array that is accessible by the functional unit circuitry. The instructions and/or data may be retrieved from the memory array and sequenced and/or buffered before the functional unit circuitry begins to execute instructions on the data. Furthermore, as different types of operations may be executed in one or multiple clock cycles through the functional unit circuitry, intermediate results of the instructions and/or data may also be sequenced and/or buffered.

In many instances, the processing resources (e.g., processor and/or associated functional unit circuitry) may be external to the memory array, and data is accessed via a bus between the processing resources and the memory array to execute a set of instructions. Typically, the memory array itself has limited capability and function. For instance, most memory arrays store the instructions to be executed and/or

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data to be operated on. Such memory arrays can include circuitry used for sensing memory cells and/or refreshing data stored therein.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a block diagram of an apparatus in the form of a computing system including a memory device in accordance with a number of embodiments of the present disclosure.

FIG. 2 illustrates a schematic diagram of a portion of a memory array configured to perform data shifting in accordance with a number of embodiments of the present disclosure.

FIG. 3 illustrates a schematic diagram of a portion of a memory array configured to perform data shifting in accordance with a number of embodiments of the present disclosure.

FIG. 4 illustrates a schematic diagram of a portion of a memory array configured to perform data shifting in accordance with a number of embodiments of the present disclosure.

FIG. 5 illustrates a schematic diagram of a portion of sensing circuitry in accordance with a number of embodiments of the present disclosure.

**DETAILED DESCRIPTION**

The present disclosure includes apparatuses and methods related to data shifting. An example apparatus comprises a first memory cell coupled to a first sense line of an array, a first isolation device located between the first memory cell and first sensing circuitry corresponding thereto, and a second isolation device located between the first memory cell and second sensing circuitry corresponding to a second sense line. The first and the second isolation devices are operated to shift data in the array without transferring the data via an input/output line of the array.

A number of embodiments of the present disclosure can provide improved functionality associated with a memory array by providing the ability to shift data within the array (e.g., from one memory cell to another memory cell) without transferring data (e.g., to an external processing resource) via input/output lines (e.g., local and/or global input/output lines) of the array. As an example, embodiments of the present disclosure can provide for shifting data in an array (e.g., along a selected access line) such that data stored in a particular memory cell can be transferred (e.g., right or left) to an adjacent memory cell coupled to the selected access line, and the data value stored in the particular memory cell can be replaced with a data value shifted from a different memory cell. Shifting data within an array in accordance with embodiments described herein can be useful for a variety of processing tasks and can provide significant time savings as compared to previous data shifting approaches in which data may be transferred out of the array, shifted, and then transferred back into the array, for instance.

In previous approaches, performing data shifting may have included transferring data from the array and sensing circuitry (e.g., via a bus comprising input/output (I/O) lines) to a processing resource such as a processor, microprocessor, and/or compute engine, which may comprise ALU circuitry and/or other functional unit circuitry configured to perform the appropriate shifting (e.g., in association with various logical operations). However, transferring data from a memory array and sensing circuitry to such processing resource(s) can involve significant power consumption.

Even if the processing resource is located on a same chip as the memory array, significant power can be consumed in moving data out of the array to the processing resource, which can involve performing a sense line address access (e.g., firing of a column decode signal) in order to transfer data from sense lines onto I/O lines (e.g., local I/O lines), moving the data to the array periphery, and providing the data to the processing resource.

Furthermore, the circuitry of the processing resource(s) (e.g., compute engine) may not conform to pitch rules associated with a memory array. For example, the cells of a memory array may have a  $4F^2$  or  $6F^2$  cell size, where “F” is a feature size corresponding to the cells. As such, the devices (e.g., logic gates) associated with ALU circuitry of previous systems may not be capable of being formed on pitch with the memory cells, which can affect chip size and/or memory density, for example. A number of embodiments of the present disclosure include isolation devices and related sensing circuitry formed on pitch with memory cells of the array and capable of being operated to perform data shifting as described further herein below. As used herein, an isolation device refers to a device, such as a transistor and/or diode, which is capable of selectively providing electrical isolation between at least a pair of nodes (e.g., terminals).

In the following detailed description of the present disclosure, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration how one or more embodiments of the disclosure may be practiced. These embodiments are described in sufficient detail to enable those of ordinary skill in the art to practice the embodiments of this disclosure, and it is to be understood that other embodiments may be utilized and that process, electrical, and/or structural changes may be made without departing from the scope of the present disclosure. As used herein, the designator “N,” particularly with respect to reference numerals in the drawings, indicates that a number of the particular feature so designated can be included. As used herein, “a number of” a particular thing can refer to one or more of such things (e.g., a number of memory arrays can refer to one or more memory arrays).

The figures herein follow a numbering convention in which the first digit or digits correspond to the drawing figure number and the remaining digits identify an element or component in the drawing. Similar elements or components between different figures may be identified by the use of similar digits. For example, 204 may reference element “04” in FIG. 2, and a similar element may be referenced as 304 in FIG. 3. As will be appreciated, elements shown in the various embodiments herein can be added, exchanged, and/or eliminated so as to provide a number of additional embodiments of the present disclosure. In addition, as will be appreciated, the proportion and the relative scale of the elements provided in the figures are intended to illustrate certain embodiments of the present invention, and should not be taken in a limiting sense.

FIG. 1 is a block diagram of an apparatus in the form of a computing system 100 including a memory device 120 in accordance with a number of embodiments of the present disclosure. As used herein, a memory device 120, a memory array 130, and/or sensing circuitry 150 might also be separately considered an “apparatus.”

System 100 includes a host 110 coupled to memory device 120, which includes a memory array 130. Host 110 can be a host system such as a personal laptop computer, a desktop computer, a digital camera, a smart phone, or a memory card reader, among various other types of hosts. Host 110 can include a system motherboard and/or back-

plane and can include a number of processing resources (e.g., one or more processors, microprocessors, or some other type of controlling circuitry). The system 100 can include separate integrated circuits or both the host 110 and the memory device 120 can be on the same integrated circuit. The system 100 can be, for instance, a server system and/or a high performance computing (HPC) system and/or a portion thereof. Although the example shown in FIG. 1 illustrates a system having a Von Neumann architecture, embodiments of the present disclosure can be implemented in non-Von Neumann architectures (e.g., a Turing machine), which may not include one or more components (e.g., CPU, ALU, etc.) often associated with a Von Neumann architecture.

For clarity, the system 100 has been simplified to focus on features with particular relevance to the present disclosure. The memory array 130 can be a DRAM array, SRAM array, STT RAM array, PCRAM array, TRAM array, RRAM array, NAND flash array, and/or NOR flash array, for instance. The array 130 can comprise memory cells arranged in rows coupled by access lines (which may be referred to herein as word lines or select lines) and columns coupled by sense lines (which may be referred to herein as digit lines or data lines). Although a single array 130 is shown in FIG. 1, embodiments are not so limited. For instance, memory device 120 may include a number of arrays 130 (e.g., a number of banks and/or sub-arrays of DRAM cells). An example DRAM array is described in association with FIGS. 2, 3, and 4.

The memory device 120 includes address circuitry 162 to latch address signals provided over an I/O bus 156 (e.g., a data bus) through I/O circuitry 164. Address signals are received and decoded by a row decoder 146 and a column decoder 166 to access the memory array 130. Data can be read from memory array 130 by sensing voltage and/or current changes on the sense lines using sensing circuitry 150. The sensing circuitry 150 can read and latch a page (e.g., row) of data from the memory array 130. The I/O circuitry 164 can be used for bi-directional data communication with host 110 over the I/O bus 156. The write circuitry 148 is used to write data to the memory array 130.

Controller 140 decodes signals provided by control bus 154 from the host 110. These signals can include chip enable signals, write enable signals, and address latch signals that are used to control operations performed on the memory array 130, including data read, data write, and data erase operations. In various embodiments, the controller 140 is responsible for executing instructions from the host 110. The controller 140 can be a state machine, a sequencer, or some other type of controller comprising hardware, software, and/or firmware.

The controller 140 includes a shift controller 170 that can control signals provided to, for instance, isolation devices in association with performing data shifting as described further herein. For example, the shift controller 170 can control shifting data (e.g., right or left) in an array (e.g., along a selected access line of an array).

An example of the sensing circuitry 150 is described further below in association with FIGS. 2, 3, 4, and 5. For instance, in a number of embodiments, the sensing circuitry 150 can comprise a number of sense amplifiers (e.g., sense amplifiers 206 shown in FIG. 2, sense amplifiers 306 shown in FIG. 3, sense amplifier 406 shown in FIG. 4, or sense amplifier 506 shown in FIG. 5) and accumulator circuitry (e.g., accumulator circuitry 231 shown in FIG. 2, 331 shown in FIG. 3, and 431 shown in FIG. 4), which may comprise

an accumulator and can be used to provide temporary storage of data values in association with data shifting as described further herein.

FIG. 2 illustrates a schematic diagram of a portion of a memory array **230** configured to perform data shifting in accordance with a number of embodiments of the present disclosure. The array **230** includes a first portion (e.g., sub-array) comprising a number of access lines **204-0** (WL0), **204-1** (WL1), **204-2** (WL2), and **204-3** (WL3) and a number of sense lines **205-0** (D0), **205-1** (D1), and **205-2** (D2). The array **230** also includes a second portion comprising a number of access lines **244-0** (WL0), **244-1** (WL1), **244-2** (WL2), and **244-3** (WL3) and a number of sense lines **265-0** (D0), **265-1** (D1), and **265-2** (D2), which serve as complementary sense lines to sense lines **205-0**, **205-1**, and **205-2**, respectively. As such, the cells **201** of array **230** are arranged in rows coupled by the access lines (e.g., word lines) and columns coupled by the sense lines (e.g., digit lines), with each column of cells **201** being associated with a pair of complementary sense lines. Embodiments are not limited to the number of columns shown in FIG. 2.

The array **230** can be, for example, a DRAM array of 1T1C (one transistor one capacitor) memory cells each comprised of an access device **202** and a storage element (e.g., transistor **402** and capacitor **403**, as shown in FIG. 4). In a number of embodiments, the memory cells **201** are destructive read memory cells (e.g., reading the data stored in the cell destroys the data such that the data originally stored in the cell is refreshed after being read).

The array **230** is coupled to sensing circuitry in accordance with a number of embodiments of the present disclosure. In this example, each pair of complementary sense lines is coupled to sensing circuitry comprising a sense amplifier (referred to generally as **206**) and an accumulator (referred to generally as **231**). For instance, sense lines **205-0/265-0** are coupled to sense amplifier **206-0** (SA0) and corresponding accumulator **231-0** (ACCUM0), sense lines **205-1/265-1** are coupled to sense amplifier **206-1** (SA1) and corresponding accumulator **231-1** (ACCUM1), and sense lines **205-2/265-2** are coupled to sense amplifier **206-2** (SA2) and corresponding accumulator **231-2** (ACCUM2). An example sense amplifier is described in association with FIG. 5, and an example accumulator is described in association with FIG. 4. Although an open digit line architecture is illustrated in FIG. 2, embodiments are not so limited. For instance, the array **230** can have a folded digit line architecture such as that shown in FIG. 4, among other digit line architectures.

The sense amps **206** can be operated to determine data (e.g., logic data value) stored in a selected cell via a sensing (e.g. read) operation. The accumulators **231** can be operated to store (e.g., temporarily) data read from memory cells in association with data shifting in accordance with embodiments described herein. As described further below, the sensing circuitry coupled to a particular digit line can be operated to sense and/or store a data value from a memory cell coupled to the particular digit line or from a memory cell coupled to a different digit line (e.g., an adjacent digit line). Embodiments are not limited to the example sensing circuitry shown in FIG. 2. For instance, sensing circuitry in accordance with a number of embodiments described herein can include current-mode sense amplifiers and/or single-ended sense amplifiers (e.g., sense amplifiers coupled to one sense line).

A number of embodiments of the present disclosure include a number of isolation devices that can be operated in association with shifting data in an array (e.g., along a

selected access line of an array such as array **230**). The isolation devices can be located between the sensing circuitry corresponding to the particular digit lines and the memory cells coupled to the digit lines. For instance, in the example shown in FIG. 2 each of the digit lines **205-0**, **205-1**, and **205-2** include three isolation devices **251-1**, **252-1**, and **253-1** located between their respective sensing circuitry and the memory cells **201**. Similarly, each of the complementary digit lines **265-0**, **265-1**, and **265-2** include three isolation devices **251-2**, **252-2**, and **253-2** located between their respective sensing circuitry and the memory cells **201**.

For instance, with reference to digit line **205-1**, an isolation device **251-1** is located between sense amplifier **206-1** and the memory cells coupled to digit line **205-1**, an isolation device **252-1** is located between sense amplifier **206-1** and the memory cells coupled to adjacent digit line **205-0**, and an isolation device **253-1** is located between sense amplifier **206-1** and the memory cells coupled to adjacent digit line **205-2**. Similarly, with reference to complementary digit line **265-1**, an isolation device **251-2** is located between sense amplifier **206-1** and the memory cells coupled to digit line **265-1**, an isolation device **252-2** is located between sense amplifier **206-1** and the memory cells coupled to adjacent digit line **265-0**, and an isolation device **253-2** is located between sense amplifier **206-1** and the memory cells coupled to adjacent digit line **265-2**.

In the example shown in FIG. 2, the isolation devices **251-1**, **252-1**, **253-1**, **251-2**, **252-2**, and **253-2** are n-channel (Nch) transistors (e.g., field-effect transistors); however, embodiments are not limited to a particular type transistor or other isolation device. In the example shown in FIG. 2 and with reference again to digit line **205-1**, a first terminal (e.g., source/drain) of the isolation device **251-1** corresponding to digit line **205-1**, a first terminal of isolation device **252-1** corresponding to digit line **205-2**, and a first terminal of isolation device **253-1** corresponding to digit line **205-0** are coupled to each other and to digit line **205-1**. A second terminal of isolation device **252-1** corresponding to digit line **205-2** is coupled to sense amplifier **206-2**, and a second terminal of isolation device **253-1** corresponding to digit line **205-0** is coupled to sense amplifier **206-0**. Also, a second terminal of isolation device **251-1** corresponding to digit line **205-1**, a first terminal of isolation device **252-1** corresponding to digit line **205-1**, and a first terminal of isolation device **253-1** corresponding to digit line **205-1** are coupled to each other and to sense amplifier **206-1**.

In a number of embodiments, the isolation devices **251-1**, **252-1**, **253-1**, **251-2**, **252-2**, and **253-2** can be formed on pitch with the memory cells **201** and/or the sensing circuitry (e.g., sense amplifiers **206** and/or accumulators **231**) of array **230**, which may conform to a particular feature size (e.g.,  $4F^2$ ,  $6F^2$ , etc.). The isolation devices **251-1**, **252-1**, **253-1**, **251-2**, **252-2**, and **253-2** can be formed in a gap between sense amplifiers **206**, which can, as compared to previous approaches, reduce the amount of space needed for such devices and/or increase the amount of space available for other circuitry. As such, apparatuses and methods for shifting data in accordance with embodiments described herein have benefits over previous approaches.

In operation, signals can be selectively provided (e.g., via shift controller **170** shown in FIG. 1) to the gates of the isolation devices **251-1**, **252-1**, **253-1**, **251-2**, **252-2**, and **253-2** in order to shift data within the array (e.g., along a selected access line of the array **230**). In the example shown in FIG. 2, the isolation devices **251-1** and **251-2** are enabled/disabled via a signal **241** (NORM), the isolation devices

**252-1** and **252-1** are enabled/disabled via a signal **242** (ShftL), and the isolation devices **253-1** and **253-2** are enabled/disabled via a signal **243** (ShftR).

Data can be shifted to the right or to the left (e.g., along a selected access line) in accordance with a number of embodiments. For example, an operation to shift a data value stored in memory cell **201-1** to the right (e.g., to memory cell **201-2**) along selected access line **204-1** can include enabling (e.g., turning on via “NORM” control signal **241**) isolation device **251-1** corresponding to digit line **205-1** while disabling (via the “ShftR” and “ShftL” control signals) the isolation devices **252-1** and **253-1**. With isolation device **251-1** enabled, a sensing (e.g., reading) operation can be performed to determine a data value stored in memory cell **201-1** (e.g., by activating the selected access line **204-1** and sense amplifier **206-1**). The sensed data value can be stored in accumulator **231-1**. The sensed data value can then be shifted to cell **201-2** by enabling (e.g., via “ShftR” control signal **243**) the isolation device **253-1** corresponding to digit line **205-1** and activating the selected access line **204-1**. As such, activating access line **204-1** while isolation device **253-1** is enabled writes the data value stored in accumulator **231-1** to memory cell **201-2**. Therefore, the data value stored in cell **201-1** is shifted to cell **201-2** without transferring the data out of the array via I/O lines and/or via a sense line address access (e.g., without firing a column decode signal such that data is transferred to circuitry external from the array and sensing circuitry via local I/O lines). It is also noted that the data value from cell **201-1** that is sensed by the sensing circuitry corresponding to digit line **205-1** is transferred to cell **201-2** without being transferred to and/or sensed by the sensing circuitry corresponding to digit line **205-2**. As such, the data value can be shifted via execution of a single (e.g., only one) sensing operation.

In a similar fashion, an operation to shift a data value stored in memory cell **201-1** to the left (e.g., to memory cell **201-0**) along selected access line **204-1** can include enabling (e.g., turning on via “NORM” control signal **241**) isolation device **251-1** corresponding to digit line **205-1** while disabling (via the “ShftR” and “ShftL” control signals) the isolation devices **252-1** and **253-1**. With isolation device **251-1** enabled, a sensing (e.g., reading) operation can be performed to determine a data value stored in memory cell **201-1** (e.g., by activating the selected access line **204-1** and sense amplifier **206-1**). The sensed data value can be shifted to cell **201-0** by enabling (e.g., turning on) the isolation device **252-1** corresponding to digit line **205-1** (e.g., via “ShftL” control signal **242**) and activating the selected access line **204-1**. As such, activating access line **204-1** while isolation device **252-1** is enabled writes the data value stored in accumulator **231-1** to memory cell **201-0**.

Although the example above focuses on shifting data from a single memory cell (e.g., **201-1**), the isolation devices **251-1**, **252-1**, and **253-1** and **251-2**, **252-2**, and **253-2** can be operated to shift data from multiple cells simultaneously. For instance, data from all of the cells coupled to a selected access line (e.g., a page of data) can be shifted to the right (e.g., via enabling isolation devices **253-1/253-2**) or to the left (e.g., via enabling isolation devices **252-1/252-2**). Also, data stored in cells coupled to digit lines **265-0**, **265-1**, and **265-2** can be shifted along access lines **244-0** to **244-3** in a similar manner as described above. Although not illustrated in FIG. 2, in a number of embodiments, isolation devices may be coupled between non-adjacent digit lines such that data can be shifted to non-adjacent memory cells. For instance, a data value stored in memory cell **201-0** may be

transferred directly to memory cell **201-2**. Moreover, in a number of embodiments, data from a particular memory cell (e.g., **201-0**) may be transferred to more than one memory cell.

FIG. 3 illustrates a schematic diagram of a portion of a memory array **330** configured to perform data shifting in accordance with a number of embodiments of the present disclosure. The array **330** includes a first portion (e.g., sub-array) comprising a number of access lines **304-0** (WL0), **304-1** (WL1), **304-2** (WL2), and **304-3** (WL3) and a number of sense lines **305-0** (D0), **305-1** (D1), and **305-2** (D2). The array **330** also includes a second portion comprising a number of access lines **344-0** (WL0), **344-1** (WL1), **344-2** (WL2), and **344-3** (WL3) and a number of sense lines **365-0** (D0<sub>-</sub>), **365-1** (D1<sub>-</sub>), and **365-2** (D2<sub>-</sub>), which serve as complementary sense lines to sense lines **305-0**, **305-1**, and **305-2**, respectively. As such, the cells **301** of array **330** are arranged in rows coupled by the access lines (e.g., word lines) and columns coupled by the sense lines (e.g., digit lines), with each column of cells **301** being associated with a pair of complementary sense lines. Embodiments are not limited to the number of columns shown in FIG. 3.

The array **330** can be, for example, a DRAM array of 1T1C (one transistor one capacitor) memory cells each comprised of an access device and a storage element (e.g., transistor **402** and capacitor **403**, as shown in FIG. 4). In a number of embodiments, the memory cells **301** are destructive read memory cells (e.g., reading the data stored in the cell destroys the data such that the data originally stored in the cell is refreshed after being read).

The array **330** is coupled to sensing circuitry in accordance with a number of embodiments of the present disclosure. In this example, each pair of complementary sense lines is coupled to sensing circuitry comprising a sense amplifier (referred to generally as **306**) and an accumulator (referred to generally as **331**). For instance, sense lines **305-0/365-0** are coupled to sense amplifier **306-0** (SA0) and corresponding accumulator **331-0** (ACCUM0), sense lines **305-1/365-1** are coupled to sense amplifier **306-1** (SA1) and corresponding accumulator **331-1** (ACCUM1), and sense lines **305-2/365-2** are coupled to sense amplifier **306-2** (SA2) and corresponding accumulator **331-2** (ACCUM2). An example sense amplifier is described in association with FIG. 5, and an example accumulator is described in association with FIG. 4.

The sense amps **306** can be operated to determine data (e.g., logic data value) stored in a selected cell via a sensing (e.g. read) operation. The accumulators **331** can be operated to store (e.g., temporarily) data read from memory cells in association with data shifting in accordance with embodiments described herein. As described further below, the sensing circuitry coupled to a particular digit line can be operated to sense and/or store a data value from a memory cell coupled to the particular digit line or from a memory cell coupled to a different digit line (e.g., an adjacent digit line). Embodiments are not limited to the example sensing circuitry shown in FIG. 3.

The array **330** includes isolation devices located between the sensing circuitry corresponding to the particular digit lines and the memory cells coupled to the digit lines. For instance, in the example shown in FIG. 3 each of the digit lines **305-0**, **305-1**, and **305-2** include a first isolation device **351-1** located between their respective sensing circuitry and the corresponding memory cells **301** and a second isolation device **355-1** located between their respective memory cells **301** and the sensing circuitry corresponding to an adjacent digit line. For instance, isolation device **355-1** corresponding

to digit line 305-0 is located between the memory cells of digit line 305-0 and the sensing circuitry corresponding to digit line 305-1, isolation device 355-1 corresponding to digit line 305-1 is located between the memory cells of digit line 305-1 and the sensing circuitry corresponding to digit line 305-2, and, although not shown in FIG. 3, the isolation device 355-1 corresponding to digit line 305-2 is located between the memory cells of digit line 305-2 and the sensing circuitry corresponding to the next adjacent digit line. Similarly, each of the complementary digits lines 365-0, 365-1, and 365-2 include a first isolation device 351-1 located between their respective sensing circuitry and the corresponding memory cells 301 and a second isolation device 355-1 located between their respective memory cells 301 and the sensing circuitry corresponding to an adjacent digit line.

As an example, with reference to digit line 305-1, an isolation device 351-1 is located between sense amplifier 306-1 and the memory cells coupled to digit line 305-1 and an isolation device 355-1 is located between sense amplifier 306-1 and the memory cells coupled to adjacent digit line 305-0. Similarly, with reference to complementary digit line 365-1, an isolation device 351-2 is located between sense amplifier 306-1 and the memory cells coupled to digit line 365-1 and an isolation device 355-2 is located between sense amplifier 306-1 and the memory cells coupled to adjacent digit line 365-0.

In the example shown in FIG. 3, the isolation devices 351-1, 355-1, 351-2, and 355-2 are n-channel (Nch) transistors (e.g., field-effect transistors); however, embodiments are not limited to a particular type transistor or other isolation device. In the example shown in FIG. 3 and with reference again to digit line 305-1, a first terminal (e.g., source/drain) of the isolation device 351-1 corresponding to digit line 305-1 and a first terminal of isolation device 355-1 corresponding to digit line 305-1 are coupled to each other and to sense amplifier 306-1. A second terminal of isolation device 355-1 corresponding to digit line 305-1 and a first terminal of isolation device 351-1 corresponding to digit line 305-0 are coupled to each other and to digit line 305-0, with a second terminal of the isolation device 351-1 corresponding to digit line 305-0 being coupled to sense amplifier 306-0. A second terminal of isolation device 351-1 corresponding to digit line 305-1 and a first terminal of isolation device 355-1 corresponding to digit line 305-2 are coupled to each other and to digit line 305-1. Also, a second terminal of the isolation device 355-1 corresponding to digit line 305-2 and a first terminal of isolation device 351-1 corresponding to digit line 305-2 are coupled to each other and to sense amplifier 306-2, with a second terminal of the isolation device 351-1 corresponding to digit line 305-2 being coupled to isolation device 355-1 corresponding to a next adjacent digit line (not shown) and to digit line 305-2.

In a number of embodiments, the isolation devices 351-1, 355-1, 351-2, and 355-2 can be formed on pitch with the memory cells 301 and/or the sensing circuitry (e.g., sense amplifiers 306 and/or accumulators 331) of array 330, which may conform to a particular feature size (e.g.,  $4F^2$ ,  $6F^2$ , etc.).

In operation, signals can be selectively provided (e.g., via shift controller 170 shown in FIG. 1) to the gates of the isolation devices 351-1, 355-1, 351-2, and 355-2 in order to shift data within the array (e.g., along a selected access line of the array 330). In the example shown in FIG. 3, the isolation devices 351-1 and 351-2 are enabled/disabled via a signal 341 (NORM), and the isolation devices 355-1 and 355-1 are enabled/disabled via a signal 345 (Shift).

Data can be shifted to the right or to the left (e.g., along a selected access line) in accordance with a number of embodiments. For example, an operation to shift a data value stored in memory cell 301-1 to the left (e.g., to memory cell 301-0) along selected access line 304-1 can include enabling (e.g., via "NORM" control signal 341) isolation device 351-1 corresponding to digit line 305-1 while disabling (via the "Shift" control signal) the isolation devices 355-1. With isolation device 351-1 enabled, a sensing (e.g., reading) operation can be performed to determine a data value stored in memory cell 301-1 (e.g., by activating the selected access line 304-1 and sense amplifier 306-1). The sensed data value can be stored in accumulator 331-1. The sensed data value can then be shifted to cell 301-0 by enabling (e.g., via "Shift" control signal 345) the isolation device 355-1 corresponding to digit line 305-1 and activating the selected access line 304-1. As such, activating access line 304-1 while isolation device 355-1 is enabled writes the data value stored in accumulator 331-1 to memory cell 301-0. Therefore, the data value stored in cell 301-1 is shifted to cell 301-0 without transferring the data out of the array via I/O lines and/or via a sense line address access (e.g., without firing a column decode signal such that data is transferred to circuitry external from the array and sensing circuitry via local I/O lines). It is also noted that the data value from cell 301-1 that is sensed by the sensing circuitry corresponding to digit line 305-1 is transferred to cell 301-0 without being transferred to and/or sensed by the sensing circuitry corresponding to digit line 305-0. As such, the data value can be shifted (e.g., to the left) via execution of a single (e.g., only one) sensing operation.

An operation to shift a data value stored in memory cell 301-1 to the right (e.g., to memory cell 301-2) along selected access line 304-1 can include enabling (e.g., via "Shift" control signal 345) isolation device 355-1 corresponding to digit line 305-2, disabling (via "NORM" control signal 341) the isolation device 351-1 corresponding to digit line 305-1, and sensing (e.g., reading) the data value stored in memory cell 301-1 (e.g., by activating the selected access line 304-1 and sense amplifier 306-2). The data value sensed by sense amplifier 306-2 can be stored in accumulator 331-2. As such, the data value stored in cell 301-1 is shifted to the sensing circuitry (e.g., accumulator 331-2) corresponding to digit line 305-2. The sensed data value can then be written from the accumulator 331-2 to memory cell 301-2 by enabling (e.g., via "NORM" control signal 341) the isolation device 351-1 corresponding to digit line 305-2 and activating the selected access line 304-1. That is, activating access line 304-1 while the isolation device 351-1 corresponding to digit line 305-2 is enabled writes the data value stored in accumulator 331-2 to memory cell 301-2.

Although the example above focuses on shifting data from a single memory cell (e.g., 301-1), the isolation devices 351-1, 355-1, 351-2, and 355-2 can be operated to shift data from multiple cells simultaneously. For instance, data from all of the cells coupled to a selected access line (e.g., a page of data) can be shifted to the left by enabling isolation devices 351-1 to read the data values stored in memory cells of particular digit lines into the respective sensing circuitry corresponding thereto and then enabling the isolation devices 355-1 to write the data values from the respective sensing circuitry to adjacent memory cells by activating the selected access line while the isolation devices 355-1 are enabled. A page of data can be shifted to the right, for example, by enabling the isolation devices 355-1 and reading the data value stored in memory cells of particular digit lines into sensing circuitry corresponding to digit lines

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adjacent to the particular digit lines. The isolation devices **351-1** can then be enabled to write the data values from the sensing circuitry to the memory cells corresponding thereto. Data stored in cells coupled to digit lines **365-0**, **365-1** and **365-2** can be shifted along access lines **344-0** to **344-3** in a similar manner as described above.

FIG. 4 illustrates a schematic diagram of a portion of a memory array **430** configured to perform data shifting in accordance with a number of embodiments of the present disclosure. In this example, the memory array **430** is a DRAM array of 1T1C (one transistor one capacitor) memory cells each comprised of an access device **402** (e.g., transistor) and a storage element **403** (e.g., a capacitor). The cells of array **430** are arranged in rows coupled by word lines **404-0** (WL0), **404-1** (WL1), **404-2**, (WL2) **404-3** (WL3), . . . , **404-N** (WLN) and columns coupled by sense lines (e.g., digit lines) **405-1** (D) and **405-2** (D<sub>−</sub>). In this example, each column of cells is associated with a pair of complementary sense lines **405-1** (D) and **405-2** (D<sub>−</sub>). Although only a single column of memory cells is illustrated in FIG. 4, embodiments are not so limited. For instance, a particular array may have a number of columns of memory cells and/or sense lines (e.g., 4,096, 8,192, 16,384, etc.). A gate of a particular memory cell transistor **402** is coupled to its corresponding word line **404-0**, **404-1**, **404-2**, **404-3**, . . . , **404-N**, a first source/drain region is coupled to its corresponding sense line **405-1**, and a second source/drain region of a particular memory cell transistor is coupled to its corresponding capacitor **403**. Although not illustrated in FIG. 4, the sense line **405-2** may also be coupled to a number of memory cells.

The array **430** is coupled to sensing circuitry in accordance with a number of embodiments of the present disclosure. In this example, the sensing circuitry comprises a sense amplifier **406** and an accumulator **431**. The sensing circuitry can be sensing circuitry **150** shown in FIG. 1. The sense amplifier **406** is coupled to the complementary sense lines D/D<sub>−</sub> corresponding to a particular column of memory cells. The sense amplifier **406** can be a sense amplifier such as sense amplifier **506** described below in association with FIG. 5. As such, the sense amp **406** can be operated to determine a data value stored in a selected cell. Embodiments are not limited to the example sense amplifier **406**.

The example shown in FIG. 4 includes isolation circuitry **471-1** located between the sense amplifier **406** and the memory cells coupled to digit line **405-1** and isolation circuitry **471-2** located between sense amplifier **406** and memory cells (not shown) coupled to complementary sense line **405-2**. The isolation circuitry **471-1** and/or **471-2** can comprise a number of isolation devices, such as a number of transistors as described in association with FIGS. 2 and 3.

In the example shown in FIG. 4, the accumulator **431** comprises a number of transistors formed on pitch with the transistors of the sense amp **406** and/or the memory cells of the array **430**, which may conform to a particular feature size (e.g.,  $4F^2$ ,  $6F^2$ , etc.). The isolation devices of circuitry **471-1** and **471-2** can also be formed on pitch with the memory cells of array **430**. The accumulator **431** can, in conjunction with the sense amp **406** and isolation circuitry **471-1/471-2**, operate to perform data shifting in accordance with embodiments described herein.

In the example illustrated in FIG. 4, the circuitry corresponding to accumulator **431** comprises five transistors coupled to each of the sense lines D and D<sub>−</sub>; however, embodiments are not limited to this example. Transistors **407-1** and **407-2** have a first source/drain region coupled to sense lines D and D<sub>−</sub>, respectively, and a second source/

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drain region coupled to a cross coupled latch (e.g., coupled to gates of a pair of cross coupled transistors, such as cross coupled NMOS transistors **408-1** and **408-2** and cross coupled PMOS transistors **409-1** and **409-2**). The cross coupled latch comprising transistors **408-1**, **408-2**, **409-1**, and **409-2** can be used to temporarily store data values in association with data shifting as described herein.

The transistors **407-1** and **407-2** can be referred to as pass transistors, which can be enabled via respective signals **411-1** (Passd) and **411-2** (Passdb) in order to pass the voltages or currents on the respective sense lines D and D<sub>−</sub> to the inputs of the cross coupled latch comprising transistors **408-1**, **408-2**, **409-1**, and **409-2**. In this example, the second source/drain region of transistor **407-1** is coupled to a first source/drain region of transistors **408-1** and **409-1** as well as to the gates of transistors **408-2** and **409-2**. Similarly, the second source/drain region of transistor **407-2** is coupled to a first source/drain region of transistors **408-2** and **409-2** as well as to the gates of transistors **408-1** and **409-1**.

A second source/drain region of transistor **408-1** and **408-2** is commonly coupled to a negative control signal **412-1** (Accumb). A second source/drain region of transistors **409-1** and **409-2** is commonly coupled to a positive control signal **412-2** (Accum). The Accum signal **412-2** can be a supply voltage (e.g., VDD) and the Accumb signal can be a reference voltage (e.g., ground). Enabling signals **412-1** and **412-2** activates the cross coupled latch comprising transistors **408-1**, **408-2**, **409-1**, and **409-2**. The activated sense amp pair operates to amplify a differential voltage between common node **417-1** and common node **417-2** such that node **417-1** is driven to one of the Accum signal voltage and the Accumb signal voltage (e.g., to one of VDD and ground), and node **417-2** is driven to the other of the Accum signal voltage and the Accumb signal voltage.

In this example, the accumulator **431** also includes inverting transistors **414-1** and **414-2** having a first source/drain region coupled to the respective digit lines D and D<sub>−</sub>. A second source/drain region of the transistors **414-1** and **414-2** is coupled to a first source/drain region of transistors **416-1** and **416-2**, respectively. The gates of transistors **414-1** and **414-2** are coupled to a signal **413** (InvD). The gate of transistor **416-1** is coupled to the common node **417-1** to which the gate of transistor **408-2**, the gate of transistor **409-2**, and the first source/drain region of transistor **408-1** are also coupled. In a complementary fashion, the gate of transistor **416-2** is coupled to the common node **417-2** to which the gate of transistor **408-1**, the gate of transistor **409-1**, and the first source/drain region of transistor **408-2** are also coupled. As such, enabling signal InvD serves to invert the data value stored in the secondary latch and drives the inverted value onto sense lines **405-1** and **405-2**.

The accumulator **431** shown in FIG. 4 can be operated (e.g., via the Passd, Passdb, Accumb, Accum, and InvD signals) to store data in association with data shifting as described above in association with FIGS. 2 and 3, for example. For instance, in operation, a data value stored in a memory cell can be sensed by activating an access line to which the cell is coupled. Activation of the selected access line enables the access transistor (e.g., **402**) corresponding to the selected cell, resulting in coupling of the sense line D to the selected memory cell (e.g., to the capacitor **403** if the cell is a 1T1C DRAM cell), which creates a differential voltage signal between the sense lines D and D<sub>−</sub>. The sense amplifier **406** activates (e.g., via application of control signals such as signals PSA and RNL<sub>−</sub> described in FIG. 5), which amplifies the differential signal between D and D<sub>−</sub>, resulting in a voltage (e.g., VDD) corresponding to a logic 1 or a voltage

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(e.g., ground) corresponding to a logic 0 being on sense line D (and the other voltage being on complementary sense line D<sub>−</sub>), such that the sensed data value is stored in the primary latch of sense amp 406.

The data value stored in sense amp 406 can be stored in the accumulator by enabling the pass transistors 407-1 and 407-2 (e.g., via respective Passd and Passdb control signals applied to control lines 411-1 and 411-2, respectively). The control signals 411-1 and 411-2 are referred to collectively as control signals 411. As used herein, various control signals, such as Passd and Passdb, may be referenced by referring to the control lines to which the signals are applied. For instance, a Passd signal can be referred to as control signal 411-1. With the pass transistors 407-1 and 407-2 enabled, the control signals Accumb and Accum are activated via respective control lines 412-1 and 412-2, which activates the latch of accumulator 431. As such, the sensed data value stored in sense amp 406 is transferred (e.g., copied) to the accumulator latch.

As described above in association with FIGS. 2 and 3, the particular memory cell to which a sense amplifier is coupled during a sensing operation can depend on which isolation devices of isolation circuitry 471-1/471-2 are enabled. For instance, a sense amplifier corresponding to a particular digit line may be coupled to a memory cell of an adjacent digit line via enabling of an isolation device such as isolation device 355-1 shown in FIG. 3 or isolation devices such as isolation devices 252-1 and 253-1 shown in FIG. 2.

FIG. 5 illustrates a schematic diagram of a portion of sensing circuitry in accordance with a number of embodiments of the present disclosure. In this example, the portion of sensing circuitry comprises a sense amplifier 506. In a number of embodiments, one sense amplifier 506 is provided for each column of memory cells in an array (e.g., array 130, 230, 330, 430). The sense amplifier 506 can be sense amplifier of a DRAM array, for instance. The sense amplifier 506 can be a sense amplifier such as sense amplifiers 206, 306, and 406 described above in association with FIGS. 2, 3, and 4, respectively.

In this example, sense amplifier 506 is coupled to a pair of complementary sense lines 505-1 ("D") and 505-2 ("D<sub>−</sub>"). As such, the sense amplifier 506 is coupled to all of the memory cells in a respective column through sense lines D and D<sub>−</sub>.

The sense amplifier 506 includes a pair of cross coupled n-channel transistors (e.g., NMOS transistors) 527-1 and 527-2 having their respective sources coupled to a negative control signal 528 (RNL<sub>−</sub>) and their drains coupled to sense lines D and D<sub>−</sub>, respectively. The sense amplifier 506 also includes a pair of cross coupled p-channel transistors (e.g., PMOS transistors) 529-1 and 529-2 having their respective sources coupled to a positive control signal 531 (PSA) and their drains coupled to sense lines D and D<sub>−</sub>, respectively.

The sense amplifier 506 includes a pair of isolation transistors 521-1 and 521-2 coupled to sense lines D and D<sub>−</sub>, respectively. The isolation transistors 521-1 and 521-2 are coupled to a control signal 522 (ISO) that, when activated, enables (e.g., turns on) the transistors 521-1 and 521-2 to connect the sense amplifier 506 to a column of memory cells. As illustrated in FIGS. 2 and 3, the sense amplifier 506 may be coupled to a first and a second memory array (e.g., sub-arrays) and can include another pair of isolation transistors coupled to a complementary control signal (e.g., ISO<sub>−</sub>), which is deactivated when ISO is deactivated such that the sense amplifier 506 is isolated from a first sub-array when sense amplifier 506 is coupled to a second sub-array, and vice versa. Also, as described above in association with

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FIGS. 2, 3, and 4, the sense amplifier 506 can be coupled to a number of other isolation devices located between the sense amplifier 506 and the corresponding sense lines D and D<sub>−</sub>, as well as a number of isolation devices located between the sense amplifier 506 and memory cells corresponding to a different (e.g., adjacent) sense amplifier.

The sense amplifier 506 also includes circuitry configured to equilibrate the sense lines D and D<sub>−</sub>. In this example, the equilibration circuitry comprises a transistor 524 having a first source/drain region coupled to an equilibration voltage 525 (dvc2), which can be equal to VDD/2, where VDD is a supply voltage associated with the array. A second source/drain region of transistor 524 is coupled to a common first source/drain region of a pair of transistors 523-1 and 523-2. The second source drain regions of transistors 523-1 and 523-2 are coupled to sense lines D and D<sub>−</sub>, respectively. The gates of transistors 524, 523-1, and 523-2 are coupled to control signal 526 (EQ). As such, activating EQ enables the transistors 524, 523-1, and 523-2, which effectively shorts sense line D to sense line D<sub>−</sub> such that the sense lines D and D<sub>−</sub> are equilibrated to equilibration voltage dvc2.

The sense amplifier 506 also includes transistors 532-1 and 532-2 whose gates are coupled to a signal 533 (COLDEC). Signal 533 may be referred to as a column decode signal or a column select signal. The sense lines D and D<sub>−</sub> are connected to respective local I/O lines 534-1 (IO) and 534-2 (IO) responsive to enabling signal 533 (e.g., to perform an operation such as a sense line access in association with a read operation). As such, signal 533 can be activated to transfer a signal corresponding to the data value (e.g., a logic data value such as logic 0 or logic 1) of the memory cell being accessed out of the array on the I/O lines 534-1 and 534-2.

In operation, when a memory cell is being sensed (e.g., read), the voltage on one of the sense lines D, D<sub>−</sub> will be slightly greater than the voltage on the other one of sense lines D, D<sub>−</sub>. The PSA signal is then driven high and the RNL<sub>−</sub> signal is driven low to activate the sense amplifier 506. The sense line D, D<sub>−</sub> having the lower voltage will turn on one of the PMOS transistor 529-1, 529-2 to a greater extent than the other of PMOS transistor 529-1, 529-2, thereby driving high the sense line D, D<sub>−</sub> having the higher voltage to a greater extent than the other sense line D, D<sub>−</sub> is driven high. Similarly, the sense line D, D<sub>−</sub> having the higher voltage will turn on one of the NMOS transistor 527-1, 527-2 to a greater extent than the other of the NMOS transistor 527-1, 527-2, thereby driving low the sense line D, D<sub>−</sub> having the lower voltage to a greater extent than the other sense line D, D<sub>−</sub> is driven low. As a result, after a short delay, the sense line D, D<sub>−</sub> having the slightly greater voltage is driven to the voltage of the PSA signal (which can be the supply voltage VDD), and the other sense line D, D<sub>−</sub> is driven to the voltage of the RNL<sub>−</sub> signal (which can be a reference potential such as a ground potential). Therefore, the cross coupled NMOS transistors 527-1, 527-2 and PMOS transistors 529-1, 529-2 serve as a sense amp pair, which amplify the differential voltage on the sense lines D and D<sub>−</sub> and serve to latch a data value sensed from the selected memory cell.

The present disclosure includes apparatuses and methods related to data shifting. An example apparatus comprises a first memory cell coupled to a first sense line of an array, a first isolation device located between the first memory cell and first sensing circuitry corresponding thereto, and a second isolation device located between the first memory cell and second sensing circuitry corresponding to a second sense line. The first and the second isolation devices are



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operated to shift data in the array without transferring the data via an input/output line of the array.

Although specific embodiments have been illustrated and described herein, those of ordinary skill in the art will appreciate that an arrangement calculated to achieve the same results can be substituted for the specific embodiments shown. This disclosure is intended to cover adaptations or variations of one or more embodiments of the present disclosure. It is to be understood that the above description has been made in an illustrative fashion, and not a restrictive one. Combination of the above embodiments, and other embodiments not specifically described herein will be apparent to those of skill in the art upon reviewing the above description. The scope of the one or more embodiments of the present disclosure includes other applications in which the above structures and methods are used. Therefore, the scope of one or more embodiments of the present disclosure should be determined with reference to the appended claims, along with the full range of equivalents to which such claims are entitled.

In the foregoing Detailed Description, some features are grouped together in a single embodiment for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the disclosed embodiments of the present disclosure have to use more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus, the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separate embodiment.

What is claimed is:

1. An apparatus, comprising:
  - a first memory cell and a second memory cell;
  - a first sense line coupled to the first memory cell;
  - a second sense line coupled to the second memory cell;
  - a first transistor device including a first node coupled to the first sense line;
  - a second transistor including a first node coupled to the second sense line;
  - a third transistor coupled between the first sense line and the second sense line;
  - a first sensing circuitry coupled to a second node of the first transistor;
  - a second sensing circuitry coupled to a second node of the second transistor; and
  - a fourth transistor coupled between the first node of the first transistor and the second node of the second transistor and including a control node coupled to a second control node supplying a second control signal.
2. The apparatus of claim 1, wherein the third transistor is coupled between the second node of the first transistor and the first node of the second transistor.
3. The apparatus of claim 2, wherein a control node of the third transistor is coupled to a first control node supplying a first control signal.
4. A method comprising:
  - reading out data from a first memory cell to a first sense line while disconnecting the first sense line from a second sensing circuitry to which the first sense line is coupled;
  - connecting the first sense line to a first sensing circuitry so that the first sensing circuitry amplifies the data on the first sense line to produce amplified data;
  - disconnecting the first sense line from the first sensing circuitry; and

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storing the amplified data into a second memory cell through a second sense line coupled to the second memory cell.

5. The method of claim 4, wherein the storing the amplified data into the second memory cell includes storing the amplified data into an accumulator.

6. The method of claim 4, wherein the amplified data is stored in the second memory cell while the first memory cell is being accessed.

7. The method of claim 4, wherein the second sensing circuitry is coupled to the first sense line via a first transistor having a first node coupled to the first sense line and a second node coupled to the second sense line.

8. The method of claim 7, wherein disconnecting the first sense line from the first sensing circuitry includes enabling a second transistor having a first node coupled to the first node of the first transistor.

9. An apparatus, comprising:

- a first word line;
- first and second sense lines each intersecting the first word line;
- first and second memory cells disposed at an intersection of the first word line and the first sense line and an intersection of the first word line and the second sense line;
- first and second sensing circuits;
- a first switch coupled between the first sense line and the first sensing circuit;
- a second switch coupled between the second sense line and the second sensing circuit; and
- a third switch coupled between the first sensing circuit and the second sense line.

10. The apparatus of claim 9, wherein the third switch is turned OFF when each of the first and second switches is turned ON, and the third switch is turned ON when each of the first and second switch is turned OFF.

11. The apparatus of claim 9, further comprising a fourth switch coupled between the first sensing circuit and the second sensing circuit.

12. The apparatus of claim 11, wherein each of the third and fourth switches is turned OFF when each of the first and second switches is turned ON, and each of the third and fourth switches is turned ON when each of the first and second switches is turned OFF.

13. The apparatus of claim 9, wherein the third switch is coupled to the first sensing line through the first switch.

14. The apparatus of claim 11, wherein the fourth switch is coupled to the second sensing line through the second switch.

15. The apparatus of claim 9, further comprising first and second accumulators provided for the first and second sensing circuits, respectively.

16. The apparatus of claim 9, wherein the first and second accumulators are formed on pitch with memory cells of an array comprising the first and second memory cells.

17. An apparatus, comprising:

- a first memory cell and a second memory cell;
- a first sense line coupled to the first memory cell;
- a second sense line coupled to the second memory cell;
- a first transistor device including a first node coupled to the first sense line;
- a second transistor including a first node coupled to the second sense line;
- a third transistor coupled between the first sense line and the second sense line;
- a first sensing circuitry coupled to a second node of the first transistor;

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a second sensing circuitry coupled to a second node of the second transistor; and  
 wherein a control node of the first transistor and a control node of the second transistor are coupled to a third control node supplying a control signal.

**18.** An apparatus, comprising:

a first memory cell and a second memory cell;  
 a first sense line coupled to the first memory cell;  
 a second sense line coupled to the second memory cell;  
 a first transistor device including a first node coupled to the first sense line;  
 a second transistor including a first node coupled to the second sense line;  
 a third transistor coupled between the first sense line and the second sense line;  
 a first sensing circuitry coupled to a second node of the first transistor;  
 a second sensing circuitry coupled to a second node of the second transistor; and

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wherein the first memory cell and the second memory cell are coupled to a same first word line.

**19.** An apparatus, comprising:

a first memory cell and a second memory cell;  
 a first sense line coupled to the first memory cell;  
 a second sense line coupled to the second memory cell;  
 a first transistor device including a first node coupled to the first sense line;  
 a second transistor including a first node coupled to the second sense line;  
 a third transistor coupled between the first sense line and the second sense line;  
 a first sensing circuitry coupled to a second node of the first transistor;  
 a second sensing circuitry coupled to a second node of the second transistor; and  
 a first accumulator coupled to the first sense line to temporarily store a data value on the first sense line.

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